

LONG TERM ASSESSMENT OF WATER QUALITY CHANGES IN LAKE MANSAR, A RAMSAR SITE (J&K, INDIA)

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ABSTRACT

Freshwater resources are indispensable for the survival of all major life forms on earth but their quality has deteriorated due to various human activities. This study reports long term changes in the water quality of a Ramsar site, Lake Mansar located in the Indian state of Jammu and Kashmir. For this, four sampling sites were marked and various water quality parameters were analysed following standard methodology on a seasonal basis for one year and compared with three separate sets of published and unpublished data spanning a period of about 25 years. Results indicated that increased anthropogenic activities have certainly altered the water quality of Lake Mansar with deterioration in some water quality parameters. However, a comparison with standard values recommended for drinking water by international organisations suggested that all the parameters were within the recommended limits.

KEYWORDS: Mansar, Ramsar Site, Lake, Water Quality, Long Term & India

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INTRODUCTION

A large number of natural freshwater lakes exist in the Himalayan region and are used for a variety of purposes like irrigation, drinking, recreation and domestic purposes by the local population. However, the impact of human activities has been markedly felt across the Himalayan region also and these pristine water bodies have been polluted and their status changed from oligotrophic to eutrophic. This change is often accompanied by a change in the biota resulting in alterations in their diversity, abundance and distribution with some pollution sensitive species being replaced by more tolerant species, hence, biodiversity loss. The situation becomes even more intense when we are talking about extremely vulnerable habitats like wetlands. Wetlands all over the world are known to harbour unique flora and fauna that is sensitive to any external stress. Ramsar convention held in Iran, 1971, is an international effort to identify and protect the wetlands having ecological importance.

One such Ramsar site located in lower Himalayas is lake Mansar that is socially and ecologically important but is under immense anthropogenic stress. Lake Mansar is a sub-tropical, rural closed lacustrine system without any surface channels and its main sources of water are subterranean springs and surface runoff. It is regarded a holy site from mythological period and thus holds a special position in the cultural and social sphere of the local population. It was given the status of Ramsar site owing to its ecological importance as it provides habitat and breeding ground for fishes and other aquatic life and many migratory birds visit the lake during winter. The lake also provides habitat to two important species of turtles, *Lissemys punctata* and *Trionyx gangeticus*, listed in CITES-IUCN Red list 2003 and very rare medusa, *Mansariella lacustris*. Owing to its domestic, religious, cultural

and recreational importance, the lake is being subjected to very high anthropogenic pressure. Performance of religious practices, increased tourism activities accompanied by developmental activities like construction of shops, restaurants, roads, boating station, view points, etc, adds to the pressure exerted by the local inhabitants. This increased pollution of lake water along with the introduction of common carp has altered the ecology of this lake. Over the years, several changes in the ecology of the lake including deterioration of water quality, altered shoreline morphology and ecological imbalance in biotic community has been inflicted as a result of the these activities in the vicinity of the lake (Chandrakiran and Sharma, 2013). Although many studies have been conducted to determine water quality of this lake (Al-Mikhlaifi et al., 2003; Kumar et al., 2006; Dutt et al., 2011; Singh and Jain, 2013; Zubair and Ahrar, 2013; Sharma and Sharma, 2014; Zuber 2015; Chauhan et al., 2016), but these are restricted to short periods of time. Tracking changes in water quality over long term is vital as short term trends in water quality may not reflect long term changes. Long term studies can reveal important shifts in water quality during the past and for the future (Behrendt et al., 1987). This has been used as a major water quality monitoring tool worldwide with studies like Behrendt et al., (1987), Turner and Rabalais (1991), Zhou et al., (2000), Eimers et al., (2005), Gammons and Duaime (2006), Kagalou et al., (2008), Maberly et al., (2008), Tátrai et al., (2008), Okamura (2008), Mida et al., (2010), Ławniczak (2016), Jacquemin et al., (2018), Xu et al., (2018), Kpodonu et al., (2019).

Hence, an attempt was made to summarise and understand the long term changes in the water quality of lake Mansar, based on the published and unpublished literature, also enriched with data collected for the purpose.

METHODOLOGY

In order to know the present status of water quality of lake Mansar, four sampling sites were marked and study was conducted on a seasonal basis. Various physical and chemical parameters of water were analysed using standard methodology.

Table 1 gives an overview of various physicochemical parameters analysed and the methodology followed

Table 1: Various Physicochemical Parameters Analysed and the Methodology Followed

PARAMETER	METHODOLOGY
Air Temperature	Mercury Bulb Thermometer (Welch, 1952)
Water Temperature	Mercury Bulb Thermometer (Welch, 1952)
Depth	Graduated Rope
Transparency	Secchi Disc (Welch, 1952)
Ph	PORTABLE FIELD Ph METER (Hanna)
Dissolved Oxygen	Sodium Azide Modification Of Wrinklers Method (A.P.H.A. 1985)
Free Carbon Dioxide	Titrimetric Method (A.P.H.A. 1985)
Carbonates	A.P.H.A. 1985
Bicarbonates	A.P.H.A. 1985
Chlorides	Argentometric Method (A.P.H.A. 1985)
Calcium	Edta- Titrimetric Method (A.P.H.A. 1985)
Magnesium	Edta- Titrimetric Method (A.P.H.A. 1985)

In order to assess the changes in the water quality over the years, we compared our data to the data reported in three separate surveys conducted earlier.

RESULTS

Long term changes in the water quality parameters of lake Mansar are depicted in table 2.

Table 2: Long Term Changes in the Water Quality Parameters of Lake Mansar

	UNIT	Mar 1989-Feb 1991 (Khajuria, 1992)		Oct 1996-Sept 1998 (Madhvi, 2001)		Mar 2009-Feb 2011 (Chandrakiran, 2011)		2015-2016 (Present Study)	
		MEAN	RANGE	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE
Depth	cms	408.83	200-592	354.34	110-570	40.21	15-110	68	32-106
Transparency	cms	259.61	45-588	196.46	74-325	36.88	15.0-100.0	54.44	21-103
Air temperature	°C	26.1	13.00-39.5	25.56	11.0-42.0	28.44	13-44	26.19	14-34
Water temperature	°C	24.04	14.5-33.0	24.50	12.8-39.5	23.76	14-33	24.66	17.5-31
pH		8.54	7.1-9.41	8.46	7.0-9.3	8.06	7.2-9.1	8.05	7.6-8.6
Dissolved oxygen	mg/l	8.56	4.00-14.67	9.15	2.4-16.6	6.16	1.6-20.0	6.5	3.2-13.2
Free carbon dioxide	mg/l	0.195	0-4.46	1.26	0-7.5	5.38	0-58	3.5	0-14.8
Carbonates	mg/l	9.31	0-25.93	9.56	0-30.1	13.925	0-66	4.01	0-12
Bicarbonates	mg/l	106.6	66.14-144.32	129.98	48.7-196.9	368.73	209.6-542.9	130.39	87.84-165.92
Chloride	mg/l	1.14	0.69-1.82	3.75	0.3-10.4	27.05	11.92-55.88	30.13	24-44
Calcium	mg/l	25.09	14.77-41.23	34.45	15.3-56.6	24.96	12.83-38.49	19.9	12.03-27.268
Magnesium	mg/l	7.67	3.12-16.4	6.3	1.2-11.8	21.84	12.15-35.47	22.50	18.47-31.10

A look at the table reveals that almost all studied parameters have undergone major changes during the period under investigation. A holistic view about these changes is provided below:

Depth

During the present study, lake depth revealed a mean value of 68 cms, having minimum depth of 32 cms and maximum depth of 106 cms. Over the years, mean water depth has shown a decreasing trend. It was 408.83 cms in 1992 and then decreased to 354.34 cms in 2001 and 40.21 cms in 2013. The present study shows a slight increase in mean depth reaching upto 68 cms when compared to 2013 data.

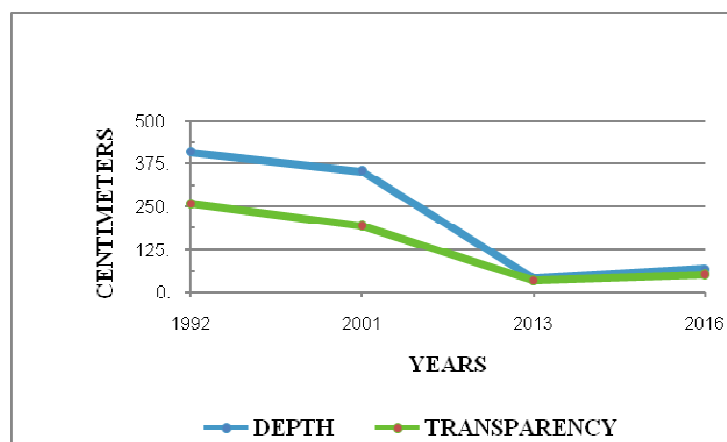


Figure 1: Change in Water Depth and Transparency over the Years

Transparency

During the present study, transparency was found upto 54.44 cms (mean value) with a range of 21-103 cms,. Over the years it has shown a decreasing trend like depth. The mean value of transparency in 1992 was 259.61 cms, that decreased to 196.46 cms in 2001, further decreasing to 36.88 cms in 2013. However, it increased to 54.44 cms during the present study.

Temperature

Temperature controls the rate of all chemical reactions and affects growth, reproduction and immunity of aquatic biota in any water body and any drastic change in this can be fatal (Patil et al., 2012). Air temperature during the study

period showed a mean value of 26.19 °C having minimum and maximum values as 14 °C and 34 °C respectively while mean value for water temperature was 24.66 °C having minimum and maximum values as 17.5 and 31 °C respectively. A comparison with the previous studies indicate that both air and water temperature has slightly risen over the years.

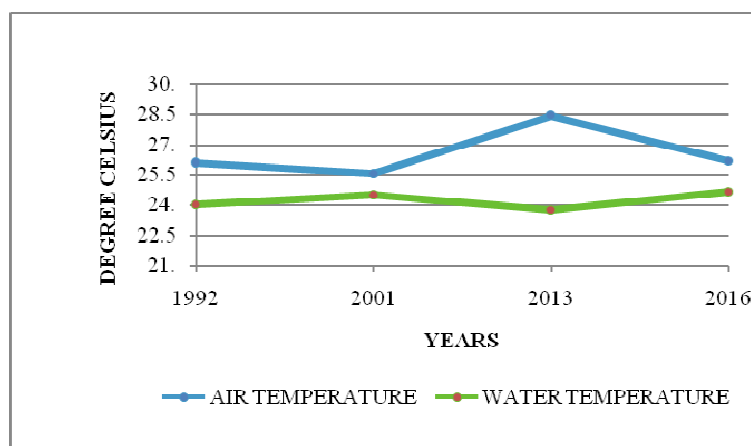


Figure 2: Change in Air and Water Temperature over the Years

pH

pH is the measure of the acidic or alkaline nature of a solution (Kumar and Puri, 2012). In natural waters, pH values are found to range from 4.5 to 10, however, the range 6.5 to 8.0 is the most common. In lake Mansar, pH has remained alkaline over the years, and the mean value at present is 8.05. A look at previous studies indicate that this has shown a slight decrease over the years. Although this decline is not marked, but increase in level of free carbon dioxide over the years may be responsible for creating acidic conditions in lake.

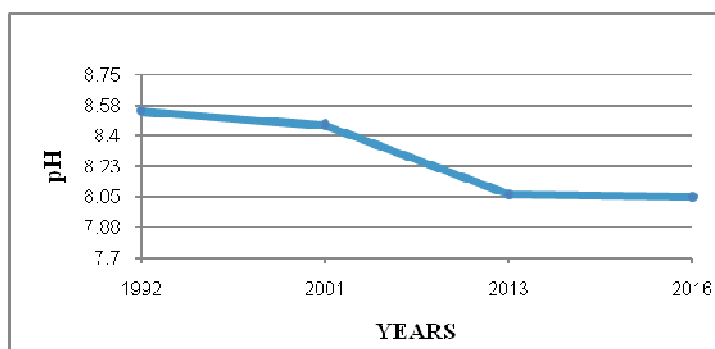


Figure 3: Change in Ph over the Years

Dissolved Oxygen

During the present study period, Dissolved Oxygen (DO) ranged from 3.2-13.2 mg/l with a mean value of 6.5 mg/l. Over the years, DO has shown a decreasing trend, ie., was 8.56 mg/l in 1992, 9.15 mg/l in 2001 and 6.16 mg/l in 2013 and 6.5 mg/l during the present study.

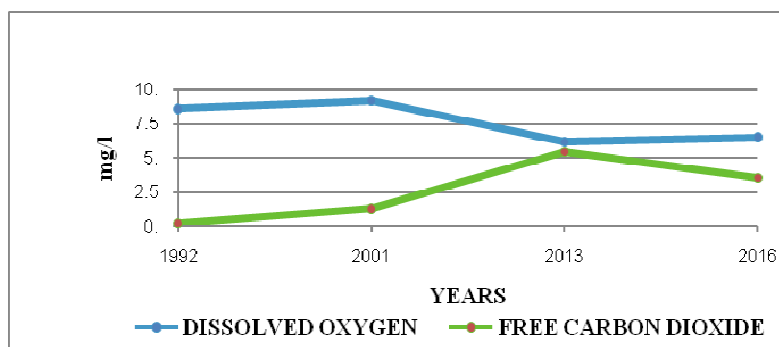


Figure 4: Change in Dissolved Oxygen and Free Carbon Dioxide over the Years

Free Carbon Dioxide

During the present study, mean value of free carbon dioxide was found to be 3.5 mg/l. A comparison with previous studies reveal that it has shown an increasing trend over the years i.e., was 0.195 mg/l in 1992, 1.26 mg/l in 2001, 5.38 mg/l in 2013 and slightly decreasing to 3.5 mg/l now.

Carbonates and Bicarbonates

Carbonates and Bicarbonates in any water body act as the source of inorganic carbon and also act as natural buffering agents in any water body. During the present study, carbonates were found to range between 0 to 12 mg/l with an average value of 4.01 mg/l. Over the years, the carbonates have shown an increasing trend with values of 9.31 mg/l in 1992, 9.56 mg/l in 2001, 13.925 mg/l in 2013 and decreased in the present study.

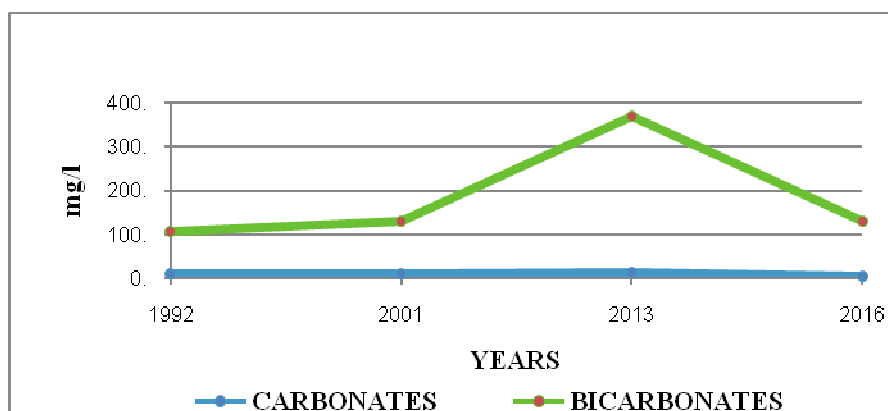


Figure 5: Change in Carbonates and Bicarbonates over the Years

Similarly, bicarbonates ranged from 87.84 mg/l to 165.92 mg/l with a mean value of 130.39 mg/l. Over the years, the bicarbonates also showed an increasing trend. Its value was 106.6 mg/l in 1992, 129.98 mg/l in 2001 and 368.73 mg/l in 2013, However, during the present study, its mean value came down to 130.39 mg/l.

Calcium and Magnesium

Calcium and Magnesium are important micronutrients that play an important role in the metabolism of aquatic organisms.

During the present study, calcium concentrations ranged from 12.03-27.27 mg/l with a mean value of 19.9 mg/l. Over the years, calcium concentration has kept on fluctuating. it was 25.09 mg/l in 1992. Then it increased upto 34.45 mg/l in 2001, then declining upto 24.96 mg/l in 2013, and 19.9 mg/l in the present study.

Similarly, magnesium ranged from 18.47 mg/l to 31.10 mg/l having the mean value of 22.50 mg/l during the present study. A look at its value over the years reveal that its concentration has kept on increasing over the years. Its value was 7.67 mg/l in 1992, 6.3 mg/l in 2001, 21.84 mg/l in 2013 and 22.50 mg/l in the present study.

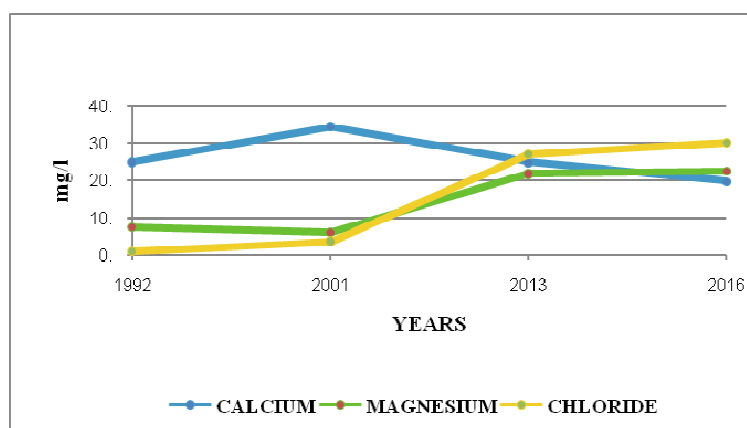


Figure 6: Change in Calcium, Magnesium and Chloride over the Years

Chloride

Chloride is another very important cation of natural water that is required for normal cell functions in plant and animal life (Kumar and Puri, 2012). Over the years, chloride has shown an increasing trend. Its mean value was 1.14 mg/l in 1992, 3.75 mg/l in 2001 and 27.05 mg/l in 2013. In the present study, it has increased upto 30.13 mg/l.

DISCUSSIONS

Change in lake physical conditions

The various physical factors like air and water temperature, depth, transparency and pH play an important role along with the chemical parameters in determining the overall environment in any waterbody.

A comparison with the previous studies indicated that both air and water temperature has slightly risen over the years. This increase in temperature could be because of the global rise in temperature.

Lake Mansar has shown a decrease in littoral depth over the years. Depth in any waterbody directly influences other physico-chemical parameters of water, habitat heterogeneity and productive volume of a lake (Welch, 1952; Gochhait, 1991; Chandrakiran, 2011). This decrease in depth over the years could be attributed to increased rate of siltation due to deforestation in catchment area as vast expanses of land have been cleared for construction of rural households and markets. Continuous water abstraction for domestic and agricultural purposes could also be a factor (Chandrakiran, 2011; Newbury and Beaty, 1971). This decrease in depth correlates with overall decrease in the size of the lake that has shrunk to near half of its size about hundred years ago (Tantray and Singh, 2012).

Another factor closely related to lake depth is transparency of water. Water transparency affects primary productivity in aquatic ecosystems by regulating the penetration of light (Hutchinson, 1957). Over the years, a decrease has been observed in the water transparency. This reduction in transparency was found correlated with water depth and this could be

because all the stations are located in the littoral zone. Also, various other factors could also be responsible for this decrease in transparency viz. formation of algal blooms, siltation and disturbance to bottom substratum by activities of biota, especially the common carp (present in exorbitant numbers).

Dissolved Oxygen and Free Carbon Dioxide Concentrations

In any aquatic ecosystem, dissolved oxygen and free carbon dioxide are two main gases whose concentration provides information about the general health of the water body. Dissolved oxygen (DO) is important for aquatic life, its level also gives information about bacterial activity, photosynthesis, availability of nutrients, stratification, etc. (Premlata Vikal, 2009, Patil et al. 2012) and adequate amount of DO characterises a good water quality (Kumar and Puri, 2012). On the other hand, Free carbon dioxide is the primary source of inorganic carbon for the process of photosynthesis (Welch, 1952, Wetzel, 2001, Chandrakiran) and is produced during organic material decomposition in all water bodies (Patil et al. 2012). In freshwater bodies, the range is usually less than 10 mg/l and more amount could have adverse effects on aquatic life.

During the monitoring period, an overall decrease in the levels of dissolved oxygen and increase in the levels of free carbon dioxide have been observed. This continuous decline in DO over the years points to an alarming situation as DO levels less than 3 mg/l are fatal to most fish (Wilson, 2010). Various factors like the introduction of common carp and its excessive growth, sewage inflow, anthropogenic influences and decomposition at bottom may be responsible for reduction in DO concentration and increased free carbon dioxide in water body (Munawar, 1970; Bohra and Bhargava, 1976; Wong et al., 1979; Chandrakiran, 2011).

However, slight improvement has been noticed during the last few years as Dissolved Oxygen levels have not reached as low as 1.6 mg/l that was observed some years ago. This could be because of the management strategies being implemented by the local authorities.

Rise in the Level of Ions

An overall increase in the concentration of all the major ions has been reported over the years. This increase could be because of enhanced lake enrichment due to various anthropogenic activities. Various direct and indirect sources including addition of domestic effluents, sewage, agricultural runoff have led to rise in the level of ions. Chloride that acts as an important indicator of organic pollution, especially sewage contamination of water, (Khare et al, 2007), has increased about 30 times over a period of less than 30 years. This points to increased pollution as high amount of chlorides is associated with high organic wastes of animals and domestic sewage effluents. (Sharma, 2013)

Comparison with Standard Values

A comparison of present values was done with the standard values recommended by W.H.O., B.I.S., etc. to know the present water quality status of lake Mansar as depicted in table 3.

Table 3: Comparison of Data with Recommended Values for Drinking Water

	W.H.O.	B.I.S.	OBSERVED VALUES (AVERAGE)
AIR TEMPERATURE °C	-	-	26.19
WATER TEMPERATURE °C	-	-	24.66
DEPTH (cms)	-	-	68
TRANSPARENCY (cms)	-	-	54.44
pH	6.5-8.5	6.5-8.5	8.05
DISSOLVED OXYGEN (mg/l)	No health based guideline value	-	6.5
FREE CARBON DIOXIDE (mg/l)	-	-	3.5
ALKALINITY (mg/l)	-	600 (as CaCO ₃)	<200
CHLORIDES (mg/l)	200	1000	30.13
CALCIUM (mg/l)	75	200	19.9
MAGNESIUM (mg/l)	50	100	22.5

A look at table.3 shows that some water quality parameters have increased but the values are still within the recommended limits.

CONCLUSIONS

From the present study and its comparison with previous studies done on water quality of lake Mansar, a clear picture about change in the ecology of lake Mansar could be observed. The increased level of pollution is an end product of various anthropogenic activities carried out in lake catchment and lake water itself. These include

- Domestic activities carried out by local inhabitants adding soaps, detergents, sewage, waste water directly into lake,
- Increased tourist activities over the years for various purposes viz., for recreational purposes like school and college picnics, family outings, etc., for religious purposes like visiting the local temple, idol immersion, mundan ceremony, cremation, etc., scientific visits by students and scholars in wildlife sanctuary, etc.,
- Construction of infrastructure allied with tourist activities viz., shops, restaurants, hotels, boating station, view point, concrete pavements, government offices and guest houses, etc.,
- Introduction of exotic common carp that is a hardy fish and is now seen in enormous numbers due to ban on fish harvesting in this lake due to religious considerations. This has replaced the local fishes and also changed the overall ecology and food web patterns of lake.
- Agricultural activities in lake catchment adding fertilizers and pesticides, that are added to lake with rain water runoff.

Hence, the need of the hour is effective management by the local administration so that various anthropogenic activities could be kept under check. This is indispensable for the conservation and sustenance of ecologically valuable water bodies.

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